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Reducing pesticide risks through social and behavior change communication: a case study of the Ukulima True campaign in Kenya

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Introduction: Although pesticides play a critical role in enhancing crop productivity, their improper use poses serious threats to health and the environment. This study assessed the effectiveness of Ukulima True campaign a Social and Behavior Change Communication (SBCC) campaign in Kenya, aimed at reducing pesticide risks by promoting safer farming practices.

Methods: A cross-sectional mixed-methods approach was used, involving surveys with 406 farmers and 12 Key Informant Interviews (KIIs) in Subukia Sub-County. Descriptive statistics such as frequencies and means were used to summarize the data. Evaluation findings were compared with the baseline values. The differences in all variables were assessed for statistical significance using chi-square test for categorical variables and t-test for continuous variables.

Results: The results show that 68% of farmers became aware of the campaign, with peer-to-peer learning and radio emerging as the most influential communication channels. The campaign led to notable behavior changes, with 86.4% of farmers adopting at least three Integrated Pest Management (IPM) practices and 85.7% regularly monitoring their fields for pests and diseases. Awareness of approved pesticides rose to 70%, while adherence to Pre-harvest Intervals (PHI) increased to 86.4%. The use of Personal Protective Equipment (PPE) during pesticide application also improved, and the uptake of Spray Service Providers (SSPs) increased to 18.6%, further reducing farmers' direct exposure to pesticides.

Discussion: This study demonstrates the value of SBCC in transforming pesticide-related behaviors in agriculture. A multi-channel, community-driven strategy proved effective in reaching diverse farmer groups and encouraging safer practices. The Ukulima True campaign successfully increased awareness and adoption of safe pesticide practices, demonstrating the potential of SBCC in risk reduction and sustainable agriculture. However, challenges remain in addressing PPE access, behavioral barriers, and gender disparities. Integrating SBCC with policy support and multi-stakeholder collaboration is crucial for sustainable pesticide risk reduction.

KEYWORDS

social and behavior change communication, pesticide risk reduction, integrated pest management, Ukulima True, safe pesticide use

1 Background

A global population that is projected to exceed 10 billion people, will generate more demand for food by 2050, requiring a significant boost in agricultural productivity to ensure food security (Saini et al., 2024; Ghosh et al., 2022). Smallholder farming plays a crucial role in global food production and serves as a key source of income in many low- and middle-income countries (LMICs) (Vogel et al., 2023; Nwanze and Fan, 2016). However, 20–40% of potential crop yields are lost annually due to weeds, pests, and diseases (FAO, 2000). Pesticides are essential for enhancing crop yields and controlling pests; however, the indiscriminate and extensive use poses risks to human health, biodiversity, and the environment (Pimentel, 2005; Jeyaratnam, 1990). The increasing reliance on chemical interventions has contributed to pesticide resistance, harm to non-target organisms such as pollinators and natural pest predators (Andrea et al., 2000), contamination of soil and water (Arias-Estévez et al., 2008), and residues in primary and derived agricultural products (Osman et al., 2010). Additionally, exposure to pesticides poses serious health risks, particularly for farmers and farm workers (Tudi et al., 2022; Kachaiyaphum et al., 2010). Farmers often associate these risks with symptoms such as headaches, dizziness, skin irritation, eye discomfort, and general body weakness (Sapbamrer et al., 2024; Kori et al., 2018) highlighting the need for safer and more responsible pesticide management practices.

As food demand continues to rise, agriculture must evolve to balance productivity with safety. Farmers will need to adopt low-risk pest management strategies to combat plant pests and diseases effectively (Singh et al., 2024; Despotović et al., 2019; Khan and Damalas, 2015). While pesticides remain an important tool, they should be considered as just one part of an integrated pest management (IPM) approach (Zhou et al., 2024), rather than the sole solution (Jallow et al., 2017). Recognizing and mitigating pesticide-related risks is essential to safeguarding human health, preserving ecosystems, and ensuring long-term food security (Singh et al., 2024). Although poor pesticide management is often attributed to a lack of farmer knowledge with training proposed as a solution, research suggests that awareness of pesticide risks is already high (Sabran and Abas, 2021; Wang et al., 2017; Yang et al., 2014; Macharia et al., 2013). However, unsafe practices persist (Jallow et al., 2017), indicating that knowledge alone is insufficient to drive practice change. This suggests the need to go beyond knowledge dissemination and explore the deeper behavioral drivers and structural challenges within the food value chain (Madaki et al., 2024; Bhandari et al., 2018). Understanding these complexities is key to identifying effective interventions that promote lasting change, particularly through Social and Behavior Change Communication (SBCC).

Several factors affect the adoption of safer pesticide practices. Economic constraints, such as the high cost of personal protective equipment (PPE) make it difficult for smallholder farmers to transition to safer methods (Blanco-Muñoz and Lacasaña, 2011). Cultural beliefs, and traditional practices also shape pesticide use, some farmers view chemical pesticides as the only reliable pest control method, while others mistakenly believe that higher doses lead to better yields (Jallow et al., 2017; Atreya et al., 2012). Additionally, limited access to alternative pest management options, such as biopesticides or training on non-chemical control methods, further restricts farmers' ability to adopt safer practices (Khan and Damalas, 2015). These challenges highlight the need for interventions that address both knowledge gaps and structural barriers to drive lasting behavior change (Jallow et al., 2017).

SBCC has emerged as a transformative strategy for promoting safer pest management. By integrating communication, social mobilization, and advocacy (John and Bassey, 2020), SBCC moves beyond simple knowledge transfer to actively engage and empower communities in adopting responsible pesticide use. Rather than focusing solely on knowledge transfer, SBCC addresses the underlying attitudes, motivations, and social norms that influence farmers' behaviors (Hauer, 2023). Using a multifaceted, research-driven approach, SBCC employs interactive, theory-based strategies to challenge social and gender norms while fostering behavior change. Drawing from disciplines such as behavioral economics, marketing, advocacy, and human-centered design (MacLeod et al., 2022; Domegan, 2021; Dessart et al., 2019; Reddy et al., 2017) SBCC ensures a comprehensive and practical approach to influencing farming practices.

The *Ukulima True* campaign in Kenya, implemented under the PlantwisePlus programme in partnership with local stakeholders, exemplifies the application of SBCC principles in promoting safer farming practices among agricultural value chain actors. The campaign specifically aimed to mitigate pesticide-related risks by delivering targeted, practical training on responsible pesticide use and disseminating behaviorally informed messages. Key messages focused on critical safety practices, including the use of PPEs, consultation with trained spray service providers (SSPs), proper sprayer calibration, procurement of approved pesticides, adherence to pre-harvest intervals, and the adoption of bio-pesticides. The campaign also promoted IPM as a holistic alternative to routine chemical applications. A multi-stakeholder engagement approach was employed, targeting not only farmers but also agro-dealers, extension personnel, policymakers, and community influencers. Each audience segment was addressed based on its role in the pesticide use ecosystem whether regulatory, advisory, or commercial influencing farmers' decision-making and behavior.

To support behavior change and reinforce key messages on safe pesticide use, the *Ukulima True* campaign employed a multi-channel communication strategy designed to reach diverse user groups according to their access to and preferences for information. Recognizing that different stakeholders consume information through different mediums, the campaign strategically tailored its outreach methods to maximize reach and impact. Peer-to-peer training sessions, led by trusted community members such as lead farmers and extension agents, facilitated practical, interpersonal learning particularly effective among farmers with limited access to mass media. Over the 6-month period, 30 trained lead farmers conducted 217 peer sessions, each lasting at least 1 h and covering seven core topics, including pest prevention, safe pesticide use and handling, monitoring, post-spraying practices, and information-seeking behavior. In total, 1,194 farmers participated in these interactive sessions.

For broader outreach, the campaign utilized radio, airing 126 radio spots and dramas over 6 weeks (21 per week), and 120 one-min audio features (20 per week), all delivered in local language (Kikuyu) to ensure accessibility and cultural relevance. In addition, three expert-led radio talk shows with live Q&A segments offered deeper listener engagement. These efforts reached an estimated 899,000 people, highlighting the importance of radio as a primary channel for mass communication. To complement audio and interpersonal messaging, the campaign produced instructional videos demonstrating safe pesticide use and IPM techniques benefitting visual learners and farmers with access to mobile devices. Printed materials such as posters and booklets were distributed through agro-dealer shops, plant clinics, and local meetings, reaching 1,200 individuals and serving as reference materials for continued learning. Furthermore, community mobilization efforts led by local leaders reached an additional 7,400 people, leveraging existing social structures to extend the campaign's influence. By layering these communication approaches combining reach with relevance the Ukulima True campaign ensured not only high message frequency but also meaningful engagement. This integrated strategy played a key role in increasing awareness and supporting the adoption of safer pesticide practices among farmers.

This study aimed to assess the effectiveness of an SBCC intervention in reducing pesticide risks within smallholder farming systems. The following research objectives guided the analysis: (1) to assess level of awareness and access to Information on the *Ukulima true* campaign between male headed households and female headed households; (2) to evaluate the influence of SBCC interventions on farmers' knowledge, attitudes, and practices regarding pesticide use; (3) to determine the extent to which smallholder farmers have changed their pesticide use behaviors and adopted safer practices as a result of the campaign. The study focused specifically on farmers because they are the primary end-users of pesticides. Their daily decisions and practices directly impact pesticide exposure risks to themselves, their families, consumers, and the environment. While other stakeholders such as agro-dealers, extension officers, and policymakers play supportive roles, assessing changes in farmers' behavior provided the most direct measure of the campaign's effectiveness in promoting safer pesticide use at the grassroots level. While behavior change campaigns have been widely used in the fields of health and development (Gebretsadik et al., 2025; Abdissa et al., 2024; Khanam and Uzair, 2024; Sood and Rimon, 2024; Solihin et al., 2023a,b), its use in agriculture remains limited. This research therefore contributes to the growing body of evidence supporting cross-sectoral applications of SBCC and underscores its potential to transform agricultural extension and risk communication, particularly in the context of pesticide safety.

1.1 Theoretical framework

The study was grounded in two theoretical frameworks—The Socio-Ecological Model (SEM) and the Health Belief Model (HBM) to systematically examine the complex drivers of pesticide use behaviors and the effectiveness of SBCC strategies in promoting safer practices among smallholder farmers (Oludoye et al., 2021; Bhandari et al., 2018). The SEM was instrumental in shaping the design of the *Ukulima True* campaign and analyzing the multi-level influences on farmer behavior. The study examined interventions at five interrelated levels: individual, interpersonal, community, organizational and policy levels. At the individual level, the campaign assessed farmers' knowledge, perceptions, and behaviors around pesticide use. Through formative study, the campaign identified key misconceptions, knowledge gaps, and behavioral patterns that contributed to risky practices. These insights guided the development of tailored messages and training materials that aimed to build personal capacity for risk recognition and safe pesticide handling.

At the interpersonal level, *Ukulima True* examined the influence of family, peers, and local influencers on pesticide-related decisions. Peer-to-peer learning and trust in local actors were found to be critical in shaping pesticide use behavior. The campaign leveraged these relationships by working through SSPs, IPM Champions, and lead farmers to facilitate trainings, share experiences, and model safe practices. At the community level, *Ukulima True* analyzed prevailing cultural norms and collective beliefs around pesticide use. The campaign identified culturally embedded behaviors and attitudes that either hindered or supported safe practices. To shift these norms, *Ukulima True* organized participatory events like field days and barazas, creating spaces for open dialogue and collective learning on pesticide safety. At the organizational level, *Ukulima True* assessed the role of institutions like county agriculture department, extension services, and agro-dealers. By partnering with these stakeholders, the campaign strengthened training and advisory and promoted consistent messaging on pesticide safety. At the policy level, *Ukulima True* considered the broader regulatory environment that shapes pesticide access, use, and monitoring. The campaign engaged with policymakers, county food safety committee, and regulatory bodies to advocate for stronger enforcement of pesticide regulations, support for training programs, and increased access to safer alternatives. This helped to create a more supportive environment for long-term behavior change.

HBM provided a behavioral lens to assess how psychological perceptions influenced farmers' decisions to adopt safe pesticide practices. According to HBM, health-related behaviors are shaped by an individual's perceived susceptibility to and severity of a risk, the perceived benefits of taking action, and the perceived barriers to doing so. In the context of pesticide safety, the *Ukulima True* campaign aimed to increase farmers' awareness of the dangers of improper pesticide use and the benefits of safer alternatives. Research shows that farmers who recognize the risks of exposure are more likely to adopt safety behaviors (Champion and Skinner, 2008). Perceived barriers significantly influence the safety behaviors of farmers; higher perceived barriers correlate with lower adherence to recommended safety measures. Factors such as time constraints, economic burdens, and discomfort due to field conditions can deter farmers from adopting safety practices (Oludoye et al., 2023). Furthermore, insufficient training and inadequately labeled safety information compound these issues. On the other hand, when farmers recognize the benefits of safety measures, they are more likely to use essential protective gear during pesticide applications, indicating that increased perceived benefits enhance adherence to safety practices (Bhandari et al., 2018).

HBM also emphasizes cues to action and self-efficacy as essential drivers of behavior change. Internal cues such as experiencing symptoms of pesticide exposure and external cues like training sessions and social media messaging can prompt farmers to take preventive action (Oludoye et al., 2023; Bhandari et al., 2018). Strengthening self-efficacy through knowledge, tools, and peer support also plays a key role in encouraging consistent safety behavior.

In the *Ukulima True* campaign, several targeted interventions were implemented to address these HBM constructs. The campaign used trusted community figures such as lead farmers, extension officers, plant doctors, and IPM Champions to deliver messages and facilitate trainings, thereby enhancing perceived credibility and reducing information gaps. Interactive learning methods, including field days, community dialogues, tactical videos, and radio programs, served as external cues to action, helping farmers better understand the practical steps needed to protect themselves. Personal testimonies from peers who had experienced pesticide-related health problems functioned as internal cues, reinforcing risk perception and motivating behavior change. To address perceived barriers, the campaign promoted affordable and accessible alternatives such as biopesticides and facilitated the use of PPE by training SSPs and equipping them with PPE to offer safe spraying services to farmers. Additionally, by fostering a culture of safety, offering repeated messaging across multiple channels, and involving farmers in co-creating solutions, the campaign strengthened self-efficacy, empowering farmers to believe they could successfully implement the recommended practices. Together, these models enabled a comprehensive understanding of both the external influences and internal motivators that shape farmers' pesticide-related behaviors. The findings contribute valuable insights into how SBCC, traditionally applied in health sectors, can be adapted to effectively address behavioral challenges in agricultural systems.

2 Methodology

2.1 Study area

The study was conducted in Subukia Sub-County in Kenya, the same area where the *Ukulima True* campaign was implemented. Subukia Sub-County consists of Kabazi, Subukia, and Waseges wards, with a total population of 85,163 (42,045 males and 43,118 females), 24,117 households, and 21,946 registered farmers. Covering an area of 401.5 km^2, the subcounty primarily practices subsistence and horticultural farming. Farmers in Subukia Sub-County are organized into 20 groups, with Subukia ward having 4,913 farmers, 16 agro-dealers, and four spray service providers. The primary languages spoken in the area include Kikuyu, Kalenjin, and Kiswahili.

2.2 Study design and sampling procedure

A cross-sectional mixed-methods approach was adopted, incorporating both quantitative and qualitative methodologies. The quantitative component consisted of household surveys, while the qualitative aspect involved Key Informant Interviews (KIIs).

2.2.1 Household survey sample size determination

Given that the farmer population was known, Yamane's (1973) formula was applied to determine the sample size:

$$n = \frac{N}{1 + N\,e^2}$$

where n = required sample size; N = total farmer population (4,913); e = margin of error (0.05)

Substituting the values, the sample size was calculated as 369 farmers. To account for potential non-response, an additional 10% (37 farmers) was included, resulting in a final sample of 406 farmers. Additionally, 12 Key Informant Interviews (KIIs) were conducted with various stakeholders, including community leaders, lead farmers, spray service providers, development partners, agricultural extension officers, and agro dealers.

2.3 Sampling procedure

The study employed a stratified sampling design and random sampling to select respondents for the quantitative survey. Respondents were categorized into two strata: P2P and non-P2P participants. This stratification was applied to reduce sampling bias and allow for comparison across different levels of exposure to the intervention. The total sample (N = 406) was evenly split between farmers who participated in P2P group learning sessions and those who did not. The P2P group consisted of farmers who were members of 30 pre-identified farmer groups that received physical, monthly group learning sessions facilitated by trained lead farmers. From each of these groups, a random sample of farmers was selected using the group membership list as the sampling frame. This ensured internal diversity and minimized self-selection bias within the P2P category.

The non-P2P group comprised farmers from the same geographic area (Subukia Ward) who were not members of the trained groups and did not participate in lead farmer-facilitated sessions but received all other project interventions. From each of the 11 villages not involved in peer-led training, farmers were randomly selected from lists of those who had never attended any P2P sessions. This approach ensured geographic comparability and minimized contamination. While P2P participation was not randomly assigned (being based on pre-existing group membership) equal sampling from similar locations helped reduce selection bias. We also conducted stratified Chi-square analysis to assess differences between P2P and non-P2P groups, helping control for confounding related to exposure.

Additionally, purposive sampling was used for KIIs to gather qualitative insights from key actors, including female and male farmers, community groups, spray service providers, county agricultural officers, and other stakeholders.

2.4 Data collection

The quantitative data were gathered through a structured questionnaire administered digitally via KoboCollect, ensuring data quality through completeness checks and GPS tracking. Qualitative data was collected through KIIs using a structured interview guide, targeting agro-dealers, extension workers, community leaders, spray service providers, development partners, and market traders. Each interview lasted ∼45 min, with measures in place to prevent respondent duplication across data collection methods.

Qualitative data from KIIs were collected through audio recordings and detailed notes. Daily data quality checks, supervision, and transcript validation ensured accuracy. Each transcript was assigned a unique identifier capturing respondent type and location. Transcripts were reviewed for quality assurance and then manually coded.

In addition, observational methods and routine field visits were employed throughout the campaign period to monitor activities, track implementation progress, and observe training sessions, group meetings, and on-farm practices. These observations enabled verification of key behaviors such as the use of PPE, checking for approved pesticide labels, and the engagement of SSPs during pesticide application.

2.5 Eligibility and ethical considerations

Informed consent for the study was obtained from all participants. Written informed consent was sought from eligible respondents, who were adults aged 20 years and above, had resided in Subukia Ward for at least 6 months, and were smallholder food producers. The written consent provided participants with detailed information about the study's purpose, procedures, and their rights, including the voluntary nature of their participation and the option to withdraw at any time without consequence. Their rights to confidentiality were also emphasized. Individuals who met the eligibility criteria but declined to provide consent were excluded from the study. The study also received ethical clearance from the relevant institutional review board, ensuring that it adhered to ethical standards for research involving human participants. Additionally, all necessary licenses and permissions for conducting the study in Subukia Sub-County were obtained from local authorities.

2.6 Statistical analysis

Quantitative data from the household survey was analyzed using Stata and MS Excel. Descriptive statistics such as frequencies and means were used to summarize the data. Evaluation findings were compared with the baseline values. The differences in all variables were assessed for statistical significance using chi-square test for categorical variables and t-test for continuous variables. Results were considered statistically significant at the 0.01, 0.05, and 0.1 levels. To address potential confounding variables, we employed stratified Chi-square analysis by disaggregating the data into subgroups such as P2P and non-P2P participants. This allowed for comparison within more homogenous groups, reducing the likelihood that observed differences were driven by underlying population characteristics rather than the intervention.

Qualitative data from KIIs was transcribed, translated, and coded for emerging themes. The coding followed a deductive approach, guided by the structure of the interview guides. A codebook was developed to support analysis, based on key concepts and emerging insights. Due to the manageable data volume, coding was conducted manually. Identified themes were organized into key categories, with flexibility to include emerging issues. Data analysis included thematic analysis, frequency comparisons, and pattern identification to address key research objectives.

Findings were then triangulated with quantitative results to validate and enrich the interpretation of the study outcomes.

3 Findings

3.1 Household sociodemographic characteristics of farmers

The results (Table 1) showed notable differences between male-headed and female-headed households, particularly in terms of education, marital status, and occupation. At the endline stage, 59.8% of households were male-headed, while 40.2% were female-headed, marking an increase from 31.1% at baseline. The majority of household heads were between 51 and 65 years old (36.3%), with younger household heads (18–30 years) remaining a small proportion (4.1%). Education levels varied significantly, as 53.3% of household heads had only primary education, and female-headed households had a higher percentage (13.9%) of individuals with no formal education compared to their male counterparts (6.5%). Additionally, a significant proportion of female household heads were widowed (27.7%) or divorced/separated (12.7%), highlighting the social factors contributing to female-headed households.

Agriculture remains the dominant livelihood, with 57.9% of household heads engaged in both crop and livestock farming, while female-headed households had a slightly higher participation rate (62.0%) compared to male-headed ones (55.1%). Full-time farm labor was more common among female-headed households (95.8%) than male-headed ones (80.2%), indicating a higher reliance on agriculture for their livelihood. Despite differences in household size, which averaged 4.5 members, and land access, which stood at 0.93 hectares on average, both groups faced similar agricultural constraints. Additionally, as shown in Table 1 there is a statistically significant association between the gender of the household head and several socio-demographic characteristics. Specifically, the education level of the HH head ($p = 0.0076$), marital status of the HH head ($p = 0.0001$), occupation of the HH head ($p = 0.0021$) and contribution of HH head to farm labor ($p = 0.00010$). Similarly, t-test results revealed significant differences between male and female-headed households in terms of household size ($p = 0.0001$) and size of land accessed at ($p = 0.0825$). These findings suggest that while female-headed households contribute significantly to agricultural labor, they may require targeted interventions such as education, training, and access to financial resources to enhance their productivity and overall economic stability.

TABLE 1 Household sociodemographic characteristics of farmers.

Variables	Categories	Overall—baseline (%)	Overall—endline ($N = 413$)	Male-headed (endline) ($N = 247$)	Female-headed (endline) ($N = 166$)	χ^2
Gender of HH head	Female	31.10	166 (40.2)	0 (0.0)	166 (100.0)	
	Male	68.90	247 (59.8)	247 (100.0)	0 (0.0)	
Age of HH head	18–24 years	0.70	3 (0.7)	2 (0.8)	1 (0.6)	
	25–30 years	3.90	14 (3.4)	11 (4.5)	3 (1.8)	
	31–40 years	16.40	69 (16.7)	43 (17.4)	26 (15.7)	
	41–50 years	24.40	101 (24.5)	57 (23.1)	44 (26.5)	
	51–65 years	37.20	150 (36.3)	94 (38.1)	56 (33.7)	0.4274
Education of HH head	Above 65 years	17.40	76 (18.4)	40 (16.2)	36 (21.7)	
	None	13.00	39 (9.4)	16 (6.5)	23 (13.9)	
	Primary	48.00	220 (53.3)	126 (51.0)	94 (56.6)	
	Secondary	33.50	131 (31.7)	87 (35.2)	44 (26.5)	
	University/college	5.00	23 (5.6)	18 (7.3)	5 (3.0)	0.0076
Marital status of HH head	Married (living with spouse)	75.10	290 (70.2)	224 (90.7)	66 (39.8)	
	Married (living without spouse)	4.30	24 (5.8)	9 (3.6)	15 (9.0)	
	Divorced/separated	4.10	26 (6.3)	5 (2.0)	21 (12.7)	
	Widow/widower	13.50	50 (12.1)	4 (1.6)	46 (27.7)	
	Never married	3.00	23 (5.6)	5 (2.0)	18 (10.8)	0.0001
Occupation of HH head	Crop farming	38.80	140 (33.9)	78 (31.6)	62 (37.3)	
	Livestock farming	0.70	1 (0.2)	1 (0.4)	0 (0.0)	
	Both crop & livestock farming	50.90	239 (57.9)	136 (55.1)	103 (62.0)	
	Salaried employment	1.40	7 (1.7)	7 (2.8)	0 (0.0)	
	Self-employed off-farm	3.70	11 (2.7)	11 (4.5)	0 (0.0)	
	Casual laborer (on-farm)	1.10	7 (1.7)	7 (2.8)	0 (0.0)	
	Casual laborer (off-farm)	2.70	6 (1.5)	5 (2.0)	1 (0.6)	0.0021
HH head contribution to farm labor	Full-time	68.50	357 (86.4)	198 (80.2)	159 (95.8)	
	Part-time	27.90	50 (12.1)	44 (17.8)	6 (3.6)	
	Not a worker	3.70	6 (1.5)	5 (2.0)	1 (0.6)	0.0001
						***t*-value**
	Household size (mean)	4.5	4.5	4.7	4.2	0.0001
	Land accessed (Ha)	0.93	0.93	0.93	0.85	0.0825

Values inside parenthesis= percentages, values outside parenthesis = frequency.

3.2 Awareness and access to information on the *Ukulima True* campaign

3.2.1 Familiarity with the Ukulima True campaign

Farmers were asked if they had heard about the *Ukulima True* campaign or seen any communication material about the campaign. Overall, 68% of farmers reported having heard of the *Ukulima True* campaign (Figure 1). Notably, female-headed households exhibited a higher awareness level (73.5%) compared to 64.4% in male-headed households. This difference could be attributed to the greater participation of female-headed households in farmer and social groups, which serve as key channels for information dissemination.

Additionally, the results highlight a difference between farmers engaged in peer-to-peer (P2P) learning groups and those who are not. A majority 98.6% of farmers in peer-to-peer groups heard of

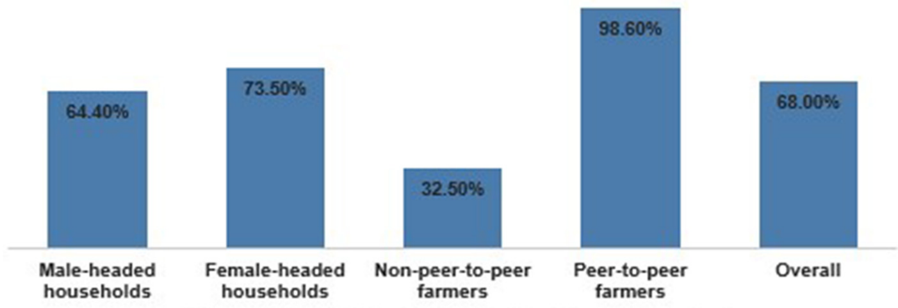

FIGURE 1
Familiarity with Ukulima True campaign.

TABLE 2 Main source of information about Ukulima True Campaign.

Source of information	Non-peer-to-peer (*N* = 168) (%)	Peer-to-peer (*N* = 209) (%)	Overall (*N* = 377) (%)
Lead farmer	38.3	81.9	73.7
Radio talk shows	53.2	47.1	48.2
Fellow neighboring farmers	29.1	34.8	33.9
Farmer groups	27.7	30.4	29.9
Posters	29.8	24.0	25.1
Community leader	25.5	5.4	9.2
Government extension agents	2.1	2.5	2.4
Internet	0.0	1.0	0.8
CBCC staff	0.0	0.5	0.4
Video dens at shopping center	2.1	0.0	0.4

the campaign, compared to only 32.5% in the non-peer-to-peer (non-P2P) group. This suggests that peer-to-peer learning played a significant role in disseminating information about the campaign.

3.2.2 Main source of information about Ukulima True campaign

Farmers reported multiple sources of information about the Ukulima True campaign (Table 2). Lead farmers were highly effective source (73.7), followed by radio talk shows (48.2%), and neighboring farmers (33.9%). Less commonly used sources included community leaders (9.2%) and government extension agents (2.4%), while digital and institutional channels such as the internet, CBCC staff, and video dens were rarely used. A stratified Chi-square analysis revealed statistically significant differences ($p < 0.05$) in information source access between peer and non-peer groups, suggesting that each relied on distinct communication channels, shaped by their level of engagement in the campaign.

3.3 Adoption of alternative pest control and management practices

The results indicate an increase in the adoption of IPM among farmers (Figure 2). Overall, 86.4% of farmers had adopted at least three IPM technologies in the 2023 cropping season, compared to 60% at baseline. IMP technologies promoted included cultural control practices such as crop rotation and the use of certified seeds and pest-resistant varieties. Mechanical and physical methods like handpicking pests, and using bio traps (e.g., pheromone and sticky traps) for pest monitoring; biological control through the use of biopesticides; and chemical control, where farmers were guided to use low-risk pesticides responsibly, only when necessary, and with proper safety measures.

Training and exposure to *Ukulima True* campaign messages also influenced farmers' adoption of alternative pest control methods. While 45.7% of farmers received training on alternative pest control, there was a gap between P2P (77.4%) and non-P2P (7.8%) farmers, indicating that training efforts were more effective among farmers engaged in knowledge-sharing networks. The training covered aspects of available biological pest control alternatives and their effectiveness, e.g., bio traps, how to maintain your farm health by using alternative pest monitoring control, that natural pest control products are very effective and are less hazardous, and that there is a need for engaging the agro-dealers and extension workers for more details on how to access alternative pest control technologies. These findings highlight the effectiveness of peer learning in promoting sustainable pest management practices and suggest a need for broader outreach to non-P2P farmers to enhance awareness and training on alternative pest control strategies.

3.3.1 Monitoring of fields for pests and diseases

The study findings revealed that 87.7% of farmers are aware of the scouting technique compared to 56.8% during baseline. However, 85.7% of farmers are monitoring (or planning to start monitoring) fields for pests and diseases compared to 45.0% during baseline (Table 3). Of the farmers practicing scouting, 80.8% scout their farms always, compared to 68% who reported scouting their fields during the baseline. Additionally, there was an increase in

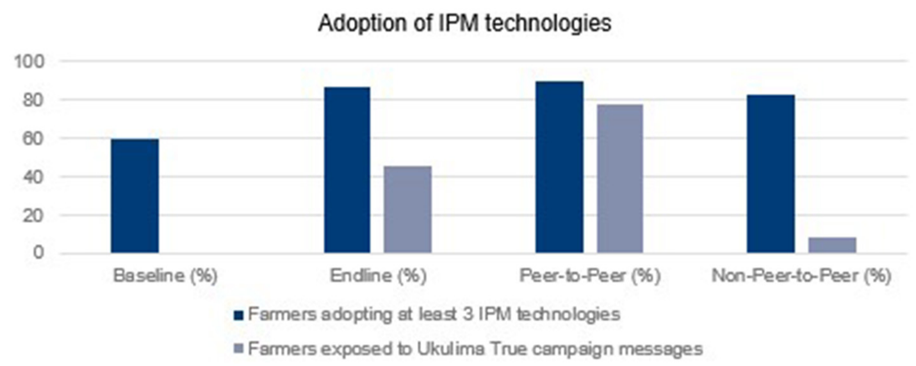

FIGURE 2
Adoption of alternative pest control and management practices.

the proportion of farmers citing different motivating factors to start scouting for pests and diseases in their farms.

3.4 Pesticide use, sourcing, and regulatory awareness

3.4.1 Pesticide use for pest and diseases control

Overall, 91.3% of farmers reported using pesticides for pest and disease control compared to 80% during baseline. The proportion of farmers using pesticides does not vary with the gender of the household head. However, there were more farmers in the peer-to-peer group (94.1%) using pesticides than those in the non-peer-to-peer group (88%). Comparing endline results and the baseline findings, more farmers were scouting for pests (88.1%) before applying pesticide compared to 32.2% during the baseline (Figure 3).

3.4.2 Farmer seeking advice or guidance on the use of pesticides

The results showed that 78.2% of farmers now seek advice on pesticide use from professionals or knowledgeable people compared to 50% during the baseline (Table 4). Male-headed households were found to be engaging professional or knowledgeable persons more (74%) compared to female-headed farmers (67%).

3.4.3 Awareness of the concept of approved pesticides and its importance

The Ukulima True campaign aimed to educate smallholder farmers about the importance of approved pesticides and the challenges of using counterfeit products. As shown in Table 5, there was anotable increase in awareness, with 70.0% of farmers aware of approved pesticides, compared to 54.8% at baseline. Several key indicators showed statistically significant changes by the endline and between P2P and non-P2P group. For instance, the proportion of farmers who checked whether the agro dealers were registered increased from 39.7 to 59.8% ($p = 0.0247$), While those who reported checking for a manufacturer's stamp/barcode increased from 9.8 to 27.7% ($p = 0.0040$). Conversely, reliance on community opinions, such as asking other farmers, decreased from 49.5% to 38.3% ($p = 0.0002$), indicating a behavioral shift toward more formal checks of product approval. Additionally, changes were observed in checking the list of registered products from PCPB (from 7.2 to 24.2%; $p = 0.0075$) and verifying quality through quality marks, with 61.6% of P2P participants doing so ($p = 0.0001$). This suggests an overall improvement in farmers' understanding of product approval criteria. However, a significant percentage of farmers still relied on mass media and agricultural specialists to ascertain product approval.

3.5 Safe use and effective pesticide application

3.5.1 Ukulima true training on safe use of pesticides

The study findings showed that 223 farmers (95.0% peer-to-peer; 6.3% non-peer-to-peer) had been trained on the safe use of pesticides. The most covered topics during the training included the need to purchase or use approved pesticides from approved agro-dealers, seeking advice from professionals like extension officers, plant doctors, integrated pest management champions, and agro-dealers, always reading the pesticide labels before using the product, and always follow instructions from product label or crop sprayer app (Table 6). The main communication strategies used were the main sources from which farmers accessed the training (Table 2).

Additionally, according to the key informants, the Ukulima True campaign significantly influenced farmers' use of pesticides. They reported that farmers have changed their perception about the safe use of pesticides, and they are now taking the initiative toward the appropriate use of pesticides. Similarly, the extension officers reported that farmers were taking plant samples that were infected by pests and diseases to Subcounty Agriculture offices for diagnosis and recommendations on appropriate control measures, which were not common before the campaign.

> *"…farmers have realized that they were making major mistakes in the application of agrochemicals without understanding the chemicals they apply by reading the label."*

> *"Now you see them keenly reading the label, being interested in knowing the chemical ingredients of the pesticide, the expired dates, and other precautionary measures of handling chemicals."* Subcounty agricultural officer, Subukia Sub County

> *"Actually, I've had a few farmers visiting the office with the samples of their diseased crops to seek advice before going to the agrovet to purchase the pesticide. This is unlike before; farmers would not take the initiative to consult the extension officers…Some even call over the phone to seek advice and book appointments."* Ward agricultural extension officer, Subukia Ward

Agro dealers reported that farmers were more eager to understand the product label than before. Farmers initially would purchase a product and walk away, but they are currently demanding the approved products whose seal is not broken.

> *"Initially, farmers would rely on their traditional knowledge and experiences and would not highly value technical advice on pesticides. Now they are embracing the guidelines given by agro dealers.* Agro dealer 1, Subukia town

> *"Currently, before the farmer picks the pesticide, they first confirm the expiry date; if the product is not labeled and has no seal, the farmer rejects it. Now they understand; it's not like before when an agro dealer would give a product to the farmer and then walk away. Now they are checking on the product features."* Agro dealer 2, Subukia town

3.5.2 Reading of pesticide labels

The end-line evaluation findings indicated that 94.2% of farmers using pesticides read labels of pesticides before using them in their farms compared to 84.5% during baseline. An assessment of whether farmers felt confident interpreting the product label revealed that more farmers were at least confident during the endline compared to baseline. However, the proportion of farmers who felt a little confident, not confident, or not confident at all was smaller during the endline compared to the baseline. Comparing end-line findings, peer-to-peer farmers were more confident in interpreting the product label compared to non-peer-to-peer farmers (Figure 4).

In assessing how often farmers follow the instructions and safety precautions on the product label, 83.9% of farmers during end line always followed, compared to 82.6% of farmers using pesticides during baseline. This could be driven by the fact that over 90% of farmers have attained at least a primary education level, which could be adequate to read and understand product labels, especially the Swahili version.

TABLE 3 Monitoring of fields for pests and diseases.

What motivated a farmer to begin scouting for pest	Baseline (%)	Endline (%)
Catch and diagnose problems early and plan for corrective action	83.2	87.3
Helps one understand the pest infestation level (severity)	31.5	58.9
Allows a farmer to predict future threats and problems	36.5	55.8
Scouting is very effective in control of pests and diseases	34.5	52.4
Helps one to know exactly where to use pesticides	29.9	50.4
Helps a farmer to correctly identify pests and diseases	30.5	37.7
It is economical—saves time and money	9.1	30.6
It's environmentally sound	5.6	21.0
It's a norm (a common practice) in this area, and every farmer does so	6.6	9.3
Curiosity to know one's farm	0	0.3

3.5.3 Use of Sprayer Service Providers (SSPs)

The Ukulima True campaign increased farmers' awareness and adoption of the Spray Service Provider (SSP), promoting safer pesticide application. As part of the campaign, select farmers received specialized training in pesticide application and subsequently offered their services to neighboring farmers. This approach minimizes direct pesticide handling by untrained individuals, reducing potential health and environmental risks.

Results show that 57.9% (84.2% peer-to-peer and 27.2% non-peer-to-peer) of farmers were aware of the existence of the SSP model compared to 22% during the baseline (Figure 5). Because of the newly trained SSPs, 43% of farmers knew an SSP in their locality with peer-to-peer farmers (65%) demonstrating greater awareness. Additionally, the proportion of farmers contracting SSP services increased from 2.7% at baseline to 18.6% at endline, with 27.9% adoption among peer-to-peer groups.

Results also revealed that female farmers had started incorporating the SSP services in their farms for spraying services as opposed to themselves undertaking the activity. Additionally, they reported that they know where to find an SSP, and they are now keeping in contact with SSPs and can make a phone call whenever they have spraying needs. According to the Subcounty Agricultural officer, the Ukulima True campaign has sensitized farmers on the dangers and risks associated with pesticide exposure.

> *"Farmers have been trained on dangers/risks of having the elderly, mothers and generally women spraying chemicals…There is a shift in perception, and women are personally keeping off any pesticide spraying."* SCAO, Subukia Subcounty.

Farmers also reported that Ukulima True campaign positively demystified rumors about the use of SSPs that previously existed

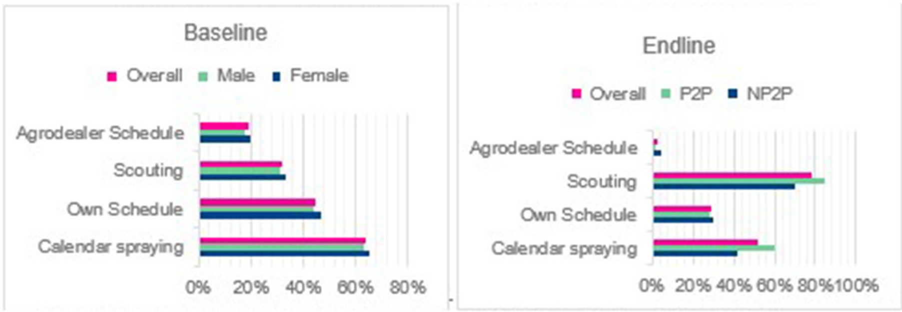

FIGURE 3
What informs a farmer when to apply pesticides (baseline vs. endline)

TABLE 4 Farmer seeking advice or guidance on the use of pesticides.

Source of advice	Baseline (%)	Endline (%)
Agro dealer	87.60	94.20
Product label/manufacturer	33.30	34.20
Other farmers	26.60	21.00
Government extension officers	15.80	13.20
Printed materials (posters and brochures)	10.70	10.50
Product promoters	17.50	7.50
NGO extension workers	3.40	6.80
Family member	5.60	5.10
Radio	22.60	4.10
TV programs	12.40	2.00
Online sources e.g., Mobile apps	6.20	1.40

in the community. Initially, farmers thought SSPs could only be used in large farms. They also believed that SSPs were expensive and could only be engaged by the rich farms. Some farmers thought that SSPs were just ordinary farmers with little experience in pesticide use and that they were just out to make a living from spraying work.

> *"…there is a significant change in farmers' use of spray service providers. The campaign has seen more SSPs trained, and now the community has spray service providers right among themselves and persons they know as."* Development partner

3.5.4 Use of Personal Protective Equipment (PPE)

The results revealed an increase in farmers' awareness and use of PPE when handling pesticides. A majority of the farmers (88.6%) were aware of the importance of using PPEs, with peer-to-peer farmers demonstrating higher awareness (97.7%) compared to non-peer-to-peer farmers. Despite the high awareness, only a smaller percentage (50.4%) was using PPEs consistently when handling pesticides (Figure 6).

According to the key informants, there was an improvement in the use of PPEs among farmers. Farmers are now demanding PPEs from the nearby agro dealer shops while the agro dealers are now stocking PPEs.

> "Previously, farmers did not use personal protective equipment (PPE) when spraying or handling pesticides, and there was little to no demand for it. However, farmers are now actively requesting PPE even from agro-dealers. In response, agro-dealers who previously did not stock PPE have now begun to do so." SCAO, Subukia Subcounty

> *"At least the community has understood the importance of using PPEs...even if they may not afford the recommended ones, somehow, they are putting on something to at least protect themselves."* Development Partner

3.5.5 Knowledge of Preharvest Interval (PHI)

As Figure 7 shows, there was a notable increase in farmers' awareness of the importance of observing the PHI, rising to 89.8% compared to the baseline. Additionally, the proportion of farmers who consistently observed PHI increased to 86.4% following the campaign. Peer-to-peer farmers demonstrated higher awareness and adherence to PHI compared to non-peer-to-peer farmers (Figure 7).

Key informants' interviews and FGDs also showed that farmers have gained some understanding of what PHI is and why it is important.

> *"…now farmers understand the meaning of PHI, they understand the different levels of chemicals, and they are producing safe food.… they understand what it means to produce safe food."* Development Partner

> *"…farmers have realized the mistake they were making. They were applying chemicals before the safe period expired. They could harvest and take to market, risking their own lives and that of their consumers."* SCAO, Subukia Subcounty

TABLE 5 Awareness of the concept of approved pesticides and its importance.

Indicator of product approval	Baseline (%)	Endline (%)	Non-P2P (%) (*N* = 168)	P2P (%) (*N* = 209)	χ^2
The product is sold by registered agro dealers	39.7	59.8	67.8	55.9	0.0247
It has a mark of quality, e.g., AAK, PCPB Number	54.5	59.3	40.2	61.6	0.0001
The product should be the one mostly used by other farmers	49.5	38.3	46	34.5	0.0323
Check for manufacturer's stamp/barcode	9.8	27.7	18.4	32.2	0.0040
Check the list of registered products from PCPB	7.2	24.2	16.1	28.2	0.0075
The product must be promoted on local radio or TV programs	18.6	10.8	17.2	19.2	0.7381
Ask an agricultural specialist	11.9	13.3	12.6	13.6	0.9176
Ask another family member	10.3	11.7	20.7	7.3	0.0002
Check the cap seal and expiry date	11.3	5.3	1.1	7.3	0.0113
Ask another community member	9.8	8.7	12.6	6.8	0.0800

> *"They (farmers) are now observing the PHI compared to when we started the campaign; farmers would spray some chemicals on wheat to fasten the drying process and make a quick sale....... Now they have started to observe the PHI and the re-entry period to that farm."* CBCC staff

TABLE 6 Ukulima true training on safe use of pesticides.

Topic covered	Proportion of trained farmers (*N* = 223) (%)
Purchasing or using approved pesticides from approved Agro dealers	89.70
Seeking advice from ESPs, plant doctors, IPM champions, and Agro dealers	89.20
Always reading the pesticide label before use	83.40
Always following instructions from the product label or crop sprayer app	77.10
Others (specify)	0.90

4 Discussion

4.1 Household sociodemographic characteristics

The findings reveal key sociodemographic differences between male-headed and female-headed households, which are important for the promotion and adoption of safe pesticide. Variables such as education, age, and attendance in extension programs significantly influence farmers' knowledge of pesticide handling (Damalas and Koutroubas, 2018; Oludoye et al., 2021; Wang et al., 2017). Female-headed households were characterized by lower levels of formal education, higher rates of widowhood or separation, and greater dependency on agriculture for their livelihoods. These social and structural disadvantages can limit women's access to critical agricultural information and training on safe pesticide use, including proper handling techniques, adherence to PHI, and correct use of PPE. Studies have shown that formal education and participation in agricultural extension services significantly improve farmers' knowledge and behavior around pesticide handling and safety (Damalas and Khan, 2016; Mohanty et al., 2013). Educated farmers are more likely to read and understand pesticide labels and follow usage guidelines (Kemabonta et al., 2014; Okoffo et al., 2016), which helps reduce pesticide risks.

Additionally, female-headed households were more engaged in full-time farm labor compared to their male counterparts. This could be attributed to several interrelated socio-economic and cultural factors. Most female-headed households result from widowhood, separation, or the absence of a male spouse, which means the woman takes on the primary responsibility for household income and food production (Kassie, 2014; Takane, 2009). With limited or no alternative sources of livelihood, these women often depend entirely on agriculture to support their families, leading to greater involvement in day-to-day farm work. Additionally, female-headed households are less likely to have access to hired labor due to financial constraints, compelling them to perform most of the agricultural tasks themselves (Mukundane et al., 2024; Reynolds et al., 2020). This contrasts with male-headed households, which may have better access to capital and social networks, enabling them to diversify their income or hire additional labor (Zhang et al., 2024; Olumba et al., 2023; Marenya et al., 2015). Cultural norms may also play a role, as men are sometimes more likely to engage in off-farm income-generating activities or manage farms at a supervisory level, while women take on more of the manual and time-intensive farming tasks. The higher participation rate of female-headed households in full-time farming suggests a stronger dependency on agriculture for household income, making them more vulnerable to pesticide risks if safety practices are not consistently followed. This is consistent with findings that link limited access to extension services and training with poor pesticide safety behavior, particularly among women (Oyekale, 2022; Memon et al., 2019).

Therefore, designing gender-sensitive interventions such as simplified farmer trainings tailored to different literacy levels, peer-to-peer learning initiatives, and increasing access to affordable PPE is crucial for improving pesticide safety. These strategies should also consider broader socio-economic factors like household size and income sources, which may influence a household's ability to invest in safety measures (Oyekale, 2022; Okonya et al., 2019). Empowering female farmers through better access to extension services, credit, and input markets could significantly enhance their capacity to adopt safer pesticide use practices, contributing to improved health outcomes and sustainable agriculture.

4.2 Awareness and access to Information on the *Ukulima True* campaign

The findings indicate that awareness and access to information about the *Ukulima True* Campaign varied across different farmer categories. Farmers who were part of peer-to-peer groups exhibited higher awareness levels than their non-peer-to-peer counterparts. This highlights the effectiveness of farmer-to-farmer (F2F) knowledge-sharing models in disseminating agricultural information, which is largely attributed to the trust they build and the reliance on local, relatable sources of knowledge (Chakraborty and Chaudhuri, 2018; Meena et al., 2016). This finding agrees with Wood et al. (2014) who found that social networks foster shared understandings, reducing cognitive gaps and making knowledge transfer more effective. Additionally, the shared understanding among socially similar individuals is particularly useful for communicating complex information (Prell et al., 2009), such as pesticide safety and IPM practices. Lead farmers played a crucial role as the primary sources of campaign information, demonstrating the value of farmer-to-farmer extension approaches in spreading knowledge about sustainable farming practices. Consistent with previous studies (Diemer et al., 2020; Elly and Epafra Silayo, 2013), smallholder farmers preferred pesticide information received through personal interactions with neighbors, and family, which also offered opportunities for observational learning (Foster and Rosenzweig, 1995).

Radio also emerged as a key communication channel, reaching 899,000 farmers across different categories. This reflects its ability to provide widespread accessibility and influence in rural areas (Adolwa et al., 2018; Rodriguez et al., 2015; Mwombe et al., 2014). However, it was less interactive compared to interpersonal sources such as lead farmers and neighboring farmers (Mwaniki et al., 2017; Mtega and Msungu, 2013). On the other hand, social groups such as farmer organizations and informal gatherings contributed to campaign awareness, particularly among female-headed households. Women farmers are more likely to participate in these groups (Kumari et al., 2023; Karaya et al., 2013), possibly explaining their higher levels of exposure to *Ukulima True* messages. This suggests that gender dynamics in agricultural communication should be considered when designing outreach strategies to ensure both male- and female-headed households have equitable access to vital information.

Agro-dealers played a crucial role in influencing farmers' purchasing decisions by providing access to safer pesticide options and offering accurate guidance on pesticide selection and application. Extension officers also served as critical sources of information, offering continuous support on safe pesticide management. However, their impact was limited, attributed to systemic challenges, such as the declining number of extension officers. This aligns with findings by Haskah et al. (2024), who noted that extension agents were less effective in disseminating agricultural information due to staff shortages and limited coverage (Loki and Mdoda, 2023). Strengthening these systems could significantly improve the reach and effectiveness of pesticide safety communication. To complement the work of extension officers, the *Ukulima True* campaign trained plant doctors, SSPs, and Ukulima True champions/lead farmers. These trained individuals worked alongside extension officers, with the extension officers providing backstopping to ensure continued support and capacity building.

Both interpersonal and mass communication channels played key roles in the *Ukulima True* campaign. Peer-to-peer interactions fostered trust and helped convey complex messages, while mass media like radio provided broad reach. Though interpersonal channels offer deeper engagement and tailored support, mass media ensures wide coverage. By combining both, the campaign effectively enhanced awareness and promoted safer pesticide practices among farmers.

4.3 Adoption of alternative pest control and management practices

The findings show a positive shift in farmers' awareness and adoption of alternative pest control and management and IPM practices, demonstrating the effect of the campaign. The use of alternative methods like biopesticides presents a sustainable approach to pest management due to their biodegradability, target specificity, and reduced environmental impact (Singh et al., 2024). According to Singh et al. (2018), incorporating biopesticides into IPM strategies can significantly enhance pest control effectiveness while preserving beneficial organisms and supporting overall ecological balance.

Farmers who engaged in peer-to-peer learning were more likely to adopt IPM compared to those who did not participate in such interactions. Training and exposure to targeted communication efforts played a critical role in enhancing farmers' understanding of alternative pest control strategies. According to Damalas and Koutroubas (2018), a farmer's intention to adopt IPM is influenced by their awareness of the adverse effects of pesticides. However, this awareness must be accompanied by a thorough understanding of pesticide risks and management strategies, rather than just a general knowledge of pesticide use (Sadique Rahman, 2022; Barron Cuenca et al., 2019; Garming and Waibel, 2007). Additionally, educating farmers about the harmful effects of pesticides (Barron Cuenca et al., 2019) and implementing a well-structured IPM awareness program that highlights its economic, social, and environmental benefits can significantly improve adoption rates. The *Ukulima True* campaign leveraged these strategies to promote safer farming practices, equipping farmers with knowledge on IPM techniques such as pest monitoring, biological control methods, and reduced pesticide reliance. By emphasizing both the risks of pesticide misuse and the advantages of IPM, the campaign

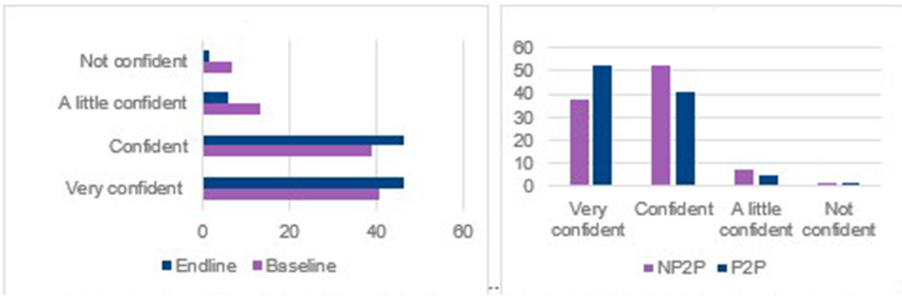

FIGURE 4
Farmer confidence level in interpreting product label baseline vs. endline.

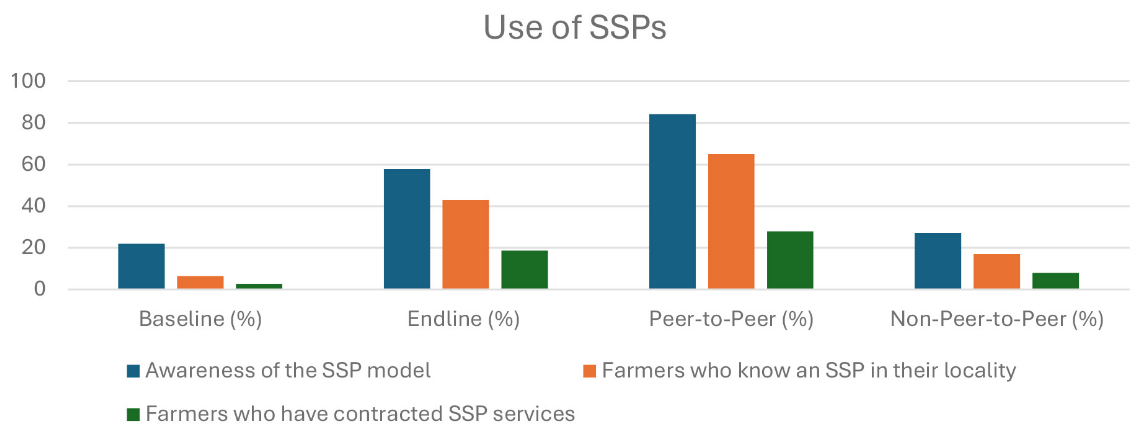

FIGURE 5
Use of Spray Service Providers (SSPs).

encouraged farmers to transition toward more sustainable pest management solutions.

There was an increase in adoption of scouting as a pest monitoring technique, demonstrating a shift toward proactive rather than reactive pest management. Farmers increasingly recognized the economic and ecological benefits of scouting, including improved decision-making on pesticide use and early detection of potential threats (LeBude et al., 2012). According to Sharma (2023), scouting is a critical component of IPM as it enables farmers to assess pest populations and make informed decisions on control measures. By identifying when pests reach economic thresholds scouting helps optimize pest control efforts and guiding on whether action is needed. However, while economic considerations were a key motivation for adoption, the environmental benefits of reduced pesticide use remain underemphasized. More efforts are needed to strengthen farmers' awareness of the long-term advantages of sustainable pest control practices. The increase in the adoption of alternative pest management strategies is an indication of a positive shift in farmer attitudes and behaviors. Strengthening farmer education, enhancing access to alternative pest control methods, and integrating environmental sustainability into pest management training could ensure lasting impact.

4.4 Pesticide use, sourcing, and regulatory awareness

The findings on pesticide sourcing highlight key factors that influence farmers' purchasing decisions and their ability to make safe choices. According to Wichai and Kessomboon (2015), pesticide sourcing and the ability to make informed, safe choices are influenced by farmers' knowledge and the types of products available in the market. Market demands also play a role in shaping pesticide use (Teng et al., 2022). The findings indicate that pesticide sourcing remains largely dependent on agro dealer shops, with a notable decline in purchases from unregulated village-based kiosks. This shift reflects improved regulatory compliance and greater farmer awareness of the risks associated with unregulated pesticide sources, reducing exposure to counterfeit or unsafe products. However, the limited presence of agro dealers in remote rural areas remains a challenge, emphasizing the need for alternative input delivery models, such as engaging lead farmers or local input promoters in pesticide distribution, alongside proper training and oversight.

There was also a notable increase in farmers seeking advice from professionals or knowledgeable individuals before using pesticides, with more farmers consulting agro dealers, extension

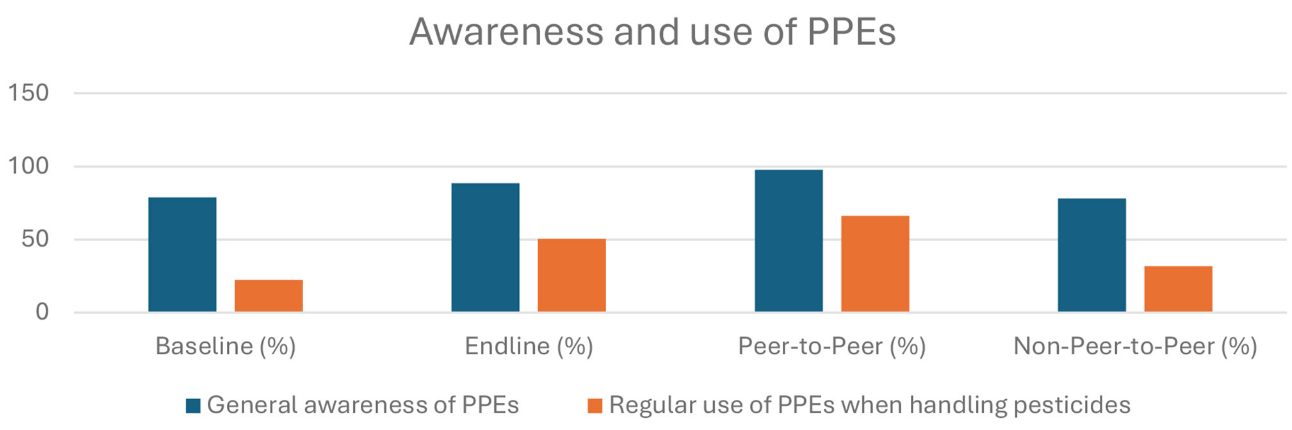

FIGURE 6
Use of Personal Protective Equipment (PPE).

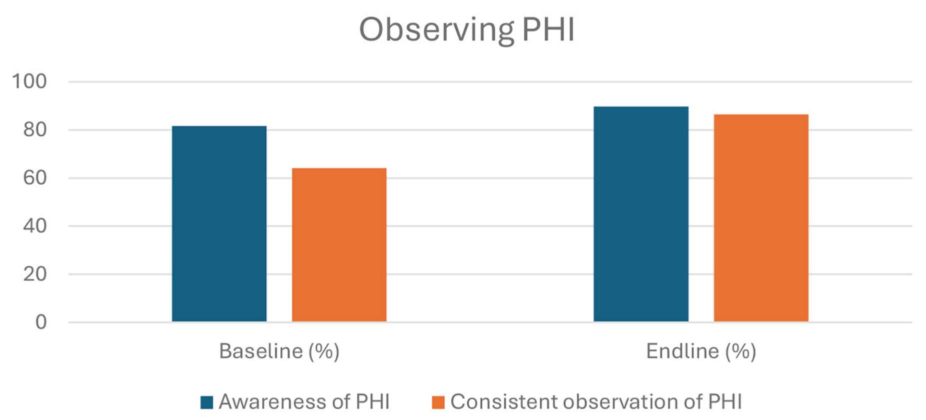

FIGURE 7
Knowledge of preharvest interval (PHI).

officers, or trained individuals before making pesticide-related decisions. However, other studies have found that farmers often rely heavily on their own prior knowledge and information from fellow farmers as the primary sources of pesticide-related advice (Madaki et al., 2024; Oludoye et al., 2021; Damalas and Khan, 2016). According to Oludoye et al. (2021) reported that cocoa farmers in Nigeria expressed dissatisfaction with the lack of reliable information on pesticide use from relevant stakeholders, often turning to other farmers and pesticide retailers, whose priority is profit rather than health and environmental concerns. This can result in the spread of misleading information, particularly if farmers lack adequate knowledge of safe pesticide practices. The study also found that male-headed households were more likely to consult professionals compared to female-headed households, indicating a potential gap in advisory services for women farmers. This highlights the need for gender-sensitive approaches to ensure that both male and female farmers have equal access to professional advice on pesticide use.

The increased awareness of approved pesticides and the risks associated with counterfeit products is a significant achievement of the *Ukulima True* Campaign. Farmers' improved ability to verify product authenticity using regulatory indicators such as the PCPB product ID and manufacturer barcodes suggest that campaign efforts in promoting safe pesticide use have been effective. This improvement is critical in combating counterfeit pesticides, which pose risks to productivity, human health, and environmental safety (Kassem et al., 2021). However, a proportion of farmers still rely on mass media to confirm product legitimacy, highlighting the need for continued education and awareness campaigns.

4.5 Safe use and effective pesticide application

The findings demonstrate the influence of the *Ukulima True* campaign on farmers' knowledge and practices regarding the safe use of pesticides. Farmers have shown notable improvements in pesticide handling, as evidenced by their increased reliance on professional advice and adherence to safety measures. The campaign's peer-to-peer training model has proven to be particularly effective, as farmers who received training through this approach exhibited higher levels of awareness and behavioral change compared to those trained through other means.

Pesticide labels are crucial as they provide essential information on the safe use and handling of pesticides, guiding farmers in making informed decisions for effective application. However, research indicates that many farmers do not read these labels, which can lead to misuse and pesticide risks (Tsakiris et al., 2023; Bagheri et al., 2021; Kapeleka and Mwaseba, 2017). According to Damalas and Khan (2016), many farmers rely on pesticide retailers for guidance rather than reading the labels themselves. Findings of this study revealed a behavioral shift, with farmers reading pesticide labels before purchasing and using them, ensuring they understand active ingredients, expiry dates, and safety precautions. This shift aligns with national regulations that require proper labeling. The campaign's emphasis on improving literacy regarding pesticide labels has helped build farmer confidence in interpreting instructions, leading to increased adherence to safety precautions. However, barriers to reading and interpreting labels still exist, such as small font sizes, technical language, and poor design, particularly for older farmers with reduced vision. These findings, echoed by Tsakiris et al. (2023), Bagheri et al. (2021), and Kapeleka and Mwaseba (2017), emphasize the need for continued education and potentially more localized language adaptations.

Spray Service Providers (SSPs) play a crucial role in reducing pesticide-related risks, particularly by offering a safer alternative for pesticide application (Tafida et al., 2021). The introduction and promotion of SSPs have gained traction, with the *Ukulima True* campaign significantly contributing to this shift by training and raising awareness about their services. The findings indicate that more farmers utilized SSP services in the study area, reducing their direct exposure to harmful chemicals. This change was especially notable among women farmers, who, after recognizing the health risks associated with pesticide spraying, shifted to using SSP services. This transition not only minimizes direct pesticide handling by untrained farmers but also enhances the perception of SSPs as skilled professionals rather than informal workers (Tafida et al., 2021). As a result, farmers viewed SSPs as valuable service providers who ensure safe pesticide application while minimizing health risks.

The use of PPEs is crucial in reducing pesticide risks (As' ady et al., 2019; Yarpuz-Bozdogan, 2018). According to Jallow et al. (2017), the likelihood of pesticide poisoning can be reduced by 44%−80% when PPE is properly used. The findings show that the *Ukulima True* campaign successfully raised awareness about the importance of PPE, leading to increased usage among farmers. For those unable to access PPE, they intentionally worked with trained SSPs, who were well-equipped and knowledgeable in safe pesticide handling. This increased awareness is crucial for mitigating health risks associated with pesticide exposure. However, despite the positive shift in practice, not all farmers consistently used PPE. Inadequate use of PPE by farmers has been reported in other contexts and countries (Oludoye et al., 2023; Aniah et al., 2021; Kansiime et al., 2019; Mequanint et al., 2019; Gesesew et al., 2016). Low compliance with the use of PPE among smallholder farmers stems from both structural and behavioral barriers. While affordability and limited accessibility remain significant challenges, behavioral factors such as discomfort due to high temperatures when wearing PPE also hinder consistent use. These findings underscore the need for a multifaceted intervention strategy. Key recommendations include facilitating access to climate-appropriate PPE through subsidies or market-based incentives, promoting the development and use of lightweight and breathable protective gear suitable for local conditions, and reinforcing behavioral change through ongoing SBCC efforts, peer education, and practical demonstrations.

4.6 Limitations of the study

This study presents important insights; however, several limitations should be acknowledged. The data were collected just 6 months into the campaign, offering a short-term view of behavioral outcomes. As such, further research is needed to assess the long-term sustainability and impact of the promoted practices. Future studies should explore continued adoption of safe pesticide use and assess how external factors, such as policy shifts or market dynamics, may influence the effectiveness of SBCC interventions over time.

Second, as with most self-reported data, there is a risk of recall bias, especially when participants were asked to reflect on past practices. In addition, social desirability bias may have influenced responses, particularly regarding pesticide safety behaviors, potentially leading to overreporting of positive behaviors.

Lastly, the findings are based on data collected in Subukia Sub-County. While efforts were made to ensure diversity within the study area, the results may have limited generalizability to other regions with different socio-cultural or agricultural contexts. However, it is worth noting that the Ukulima True campaign has since been scaled out to other regions, providing opportunities for future studies to explore its broader applicability and impact.

4.7 Lessons learned

The *Ukulima True* campaign, implemented through the PlantwisePlus programme, demonstrated that SBCC is a highly adaptable framework that extends beyond its traditional use in the health sector. While SBCC has typically been employed to influence behaviors around disease prevention and health service uptake, its application in agriculture specifically in pesticide risk reduction proved equally powerful. Concepts such as perceived susceptibility and severity, cues to action, and social reinforcement were successfully used to influence how farmers perceive and manage pesticide risks.

A multi-channel communication strategy proved critical in effectively reaching farmers with diverse levels of access and communication preferences. The campaign leveraged a mix of interpersonal communication, radio (spots and drama), video, printed materials, and digital platforms to deliver consistent, repeated messages across different contexts. This diversified approach expanded the campaign's reach by addressing variations in literacy, gendered access to information, and digital connectivity. The use of local languages and culturally appropriate content further enhanced message comprehension and retention. However, the campaign also revealed differential effectiveness across these communication channels, highlighting the need to assess not just the availability of media in rural settings, but also farmers' preferred modes of receiving information. A key insight from the campaign is the superior effectiveness of community-led approaches in catalyzing behavior change. Peer-to-peer training, farmer group discussions, and participatory learning activities, were preferred as they are based on trust and allow for the contextualization of technical messages, making them more relatable and actionable for smallholder farmers.

Beyond access to information, the campaign highlighted the significance of addressing behavioral barriers that hinder the adoption of safer practices. For example, many farmers reported discomfort in using personal protective equipment (PPE) under hot field conditions. Rather than focusing solely on knowledge dissemination, SBCC interventions can address these behavioral challenges through relatable messaging, positive reinforcement, and practical demonstrations. Furthermore, the campaign should actively work to address systemic barriers by lobbying for supportive policies and engaging a broad range of stakeholders, including government agencies, agro-dealers, and the private sector to ensure the consistent availability and affordability of appropriate PPEs.

Gender-responsive communication strategies were also found to be essential for equitable impact. The study found disparities in access to campaign information between male- and female-headed households, often due to time constraints, social norms, or lower access to extension services. Targeted efforts to reach women such as engaging women's groups and using female role models in campaign messaging are important to improve inclusivity and knowledge uptake among women farmers. Finally, policy alignment and institutional support were identified as important enablers for sustained behavior change. Collaboration with county governments, regulatory bodies, and private sector actors such as pesticide manufacturers and distributors ensured that the SBCC campaign was anchored within broader agricultural development goals. Such alignment enhances credibility, ensures the availability of complementary inputs (e.g., quality-assured PPE, biopesticides), and supports scalability.

4.8 Cost and scalability

While a formal cost-effectiveness analysis was not conducted, the Ukulima True campaign was designed with cost efficiency and scalability in mind by leveraging existing systems, community structures, and partnerships. Its structure allowed for other organizations and stakeholders to plug in through collaborations for example, through joint implementation with county governments, food safety committees, and other organizations. This model reduces the financial burden on a single institution and promotes resource sharing across sectors.

Additionally, the presence of a well-documented campaign blueprint and SBCC strategy further enhances scalability and replicability. The strategy can be adapted or updated and refined based on ongoing Monitoring and Evaluation (M&E) findings, enabling it to remain responsive to evolving farmer needs and contextual realities. These design elements contribute to the feasibility of replication in other counties and regions and enhance the sustainability of behavior change by embedding campaign efforts within local systems and governance structures.

5 Conclusion and recommendations

The *Ukulima True* Campaign successfully increased farmer awareness and the uptake of safer, more sustainable agricultural practices by leveraging community-led approaches. Among the various communication channels used, peer-to-peer interactions and radio emerged as the most effective, demonstrating the power of trusted, community-based platforms in influencing behavior change. However, with data collected only 6 months into the campaign, further research is needed to evaluate the long-term sustainability and impact of these practices. Future studies should focus on the continued adoption of safe pesticide practices and the influence of external factors like policy changes on the long-term success of SBCC efforts.

To build on the campaign's success, it's important to engage more non-peer-to-peer farmers, strengthen partnerships with agro-dealers and policymakers to create a supportive environment for the adoption of safer pesticide practices. Gender-responsive communication strategies should also be employed to address barriers faced by women farmers, ensuring equitable access to information for both male- and female-headed households. Additionally, continued collaboration with private sector actors will help ensure the availability of essential resources, such as PPE and biopesticides.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by CABI Ethics Review Board (ERB). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MN: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing. MK: Conceptualization, Data curation, Formal analysis, Resources, Validation, Writing – original draft, Writing – review & editing. TD: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. GR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. RN: Conceptualization, Data curation, Formal analysis, Investigation, Project administration, Writing – original draft, Writing – review & editing. AM: Conceptualization, Writing – original draft, Writing – review & editing. BO: Writing – original draft, Writing – review & editing. MB: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Resources, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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